Watershed modeling and monitoring for assessing nutrient trading viability and increasing the adoption of nutrient management practices

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Introduction and Overview

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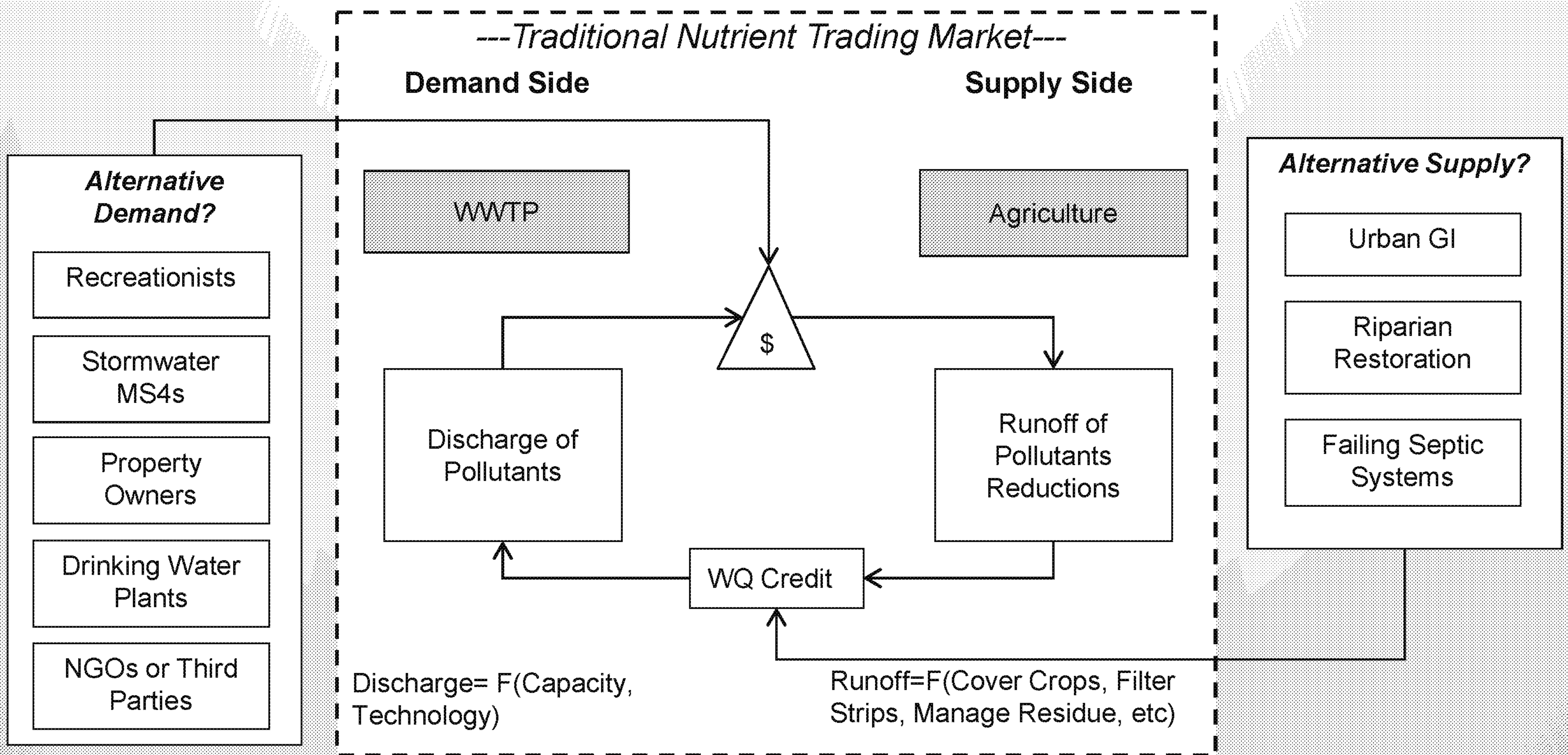
- Modeling and monitoring for studying water quality trading feasibility
- Build from work conducted in the Chesapeake Bay Region and the Wabash Study (IN)
- Intention: Understand if we can expand market potential by determining incentives for alternative participants, explain and decrease uncertainty, and increase the adoption rate of agricultural BMPs (agBMPs)
- **Review, evaluate, and validate existing modeling frameworks**
  - **Capture uncertainty in watershed loads and management effectiveness**
  - **Determine advantages and disadvantages of using the Soil Water Assessment Tool (SWAT) as one comprehensive watershed simulation tool**
- This presentation gives overview of latest modeling results for market feasibility considerations. Under preparation:
  - *Report on modeling-monitoring results for considering market feasibility and fixing nutrient enrichment of Harsha Lake*
  - *Report on advantages and disadvantages of using SWAT*
  - *Report on WWTP and agBMP effectiveness costing methodology*

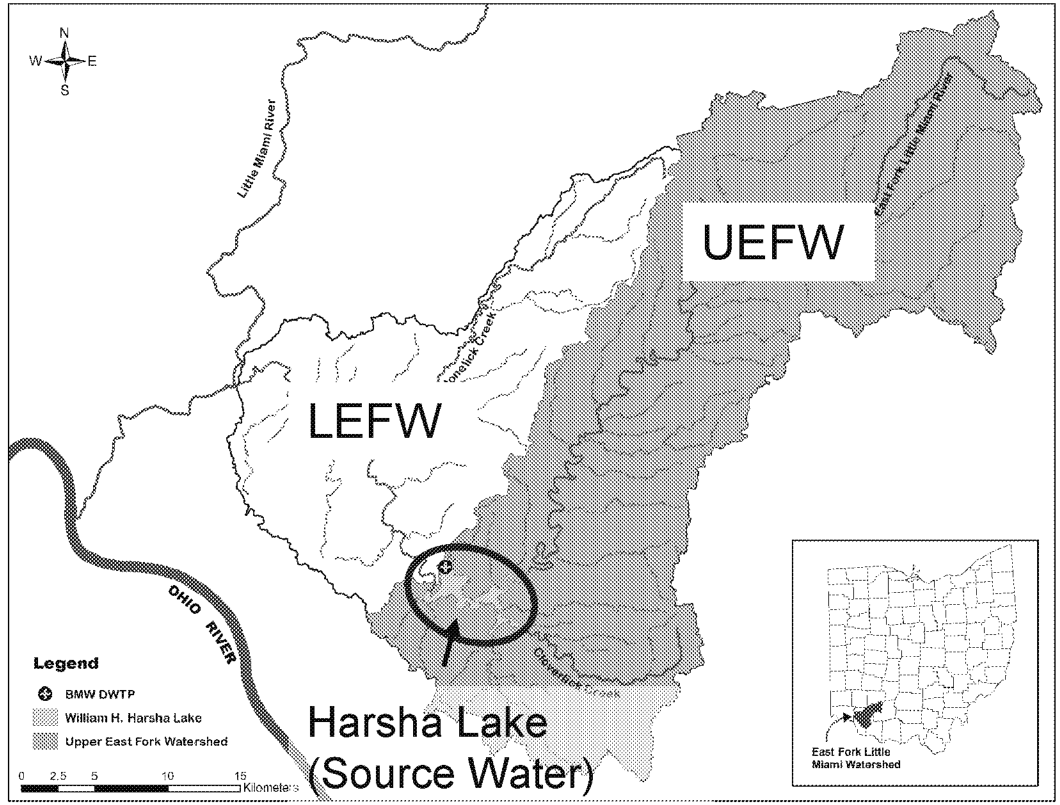
Proposal: Augmenting nutrient trading markets with non-traditional participants



Case Study System

- East Fork of the Little Miami River Watershed and William H. Harsha Lake

EFWCoop



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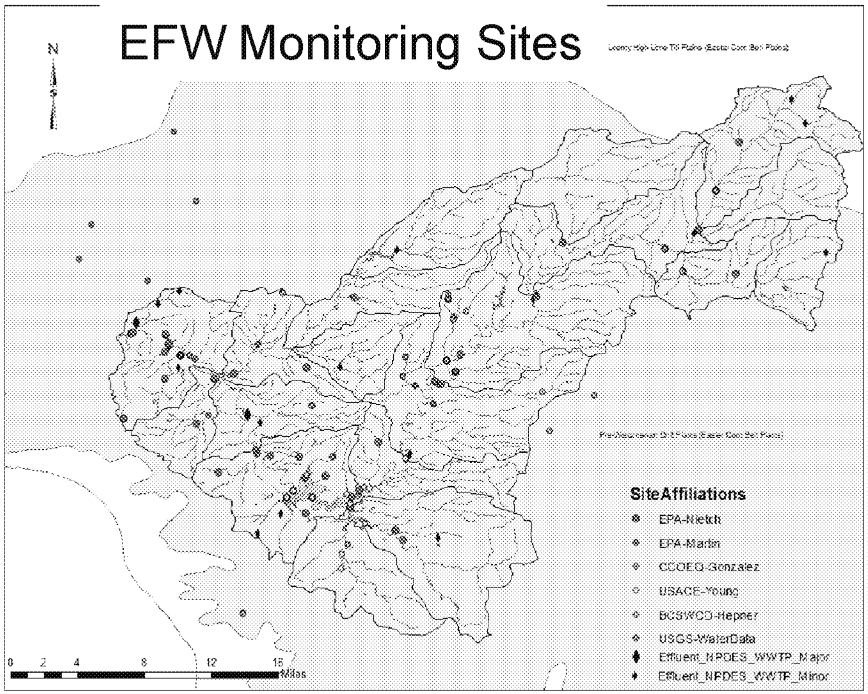
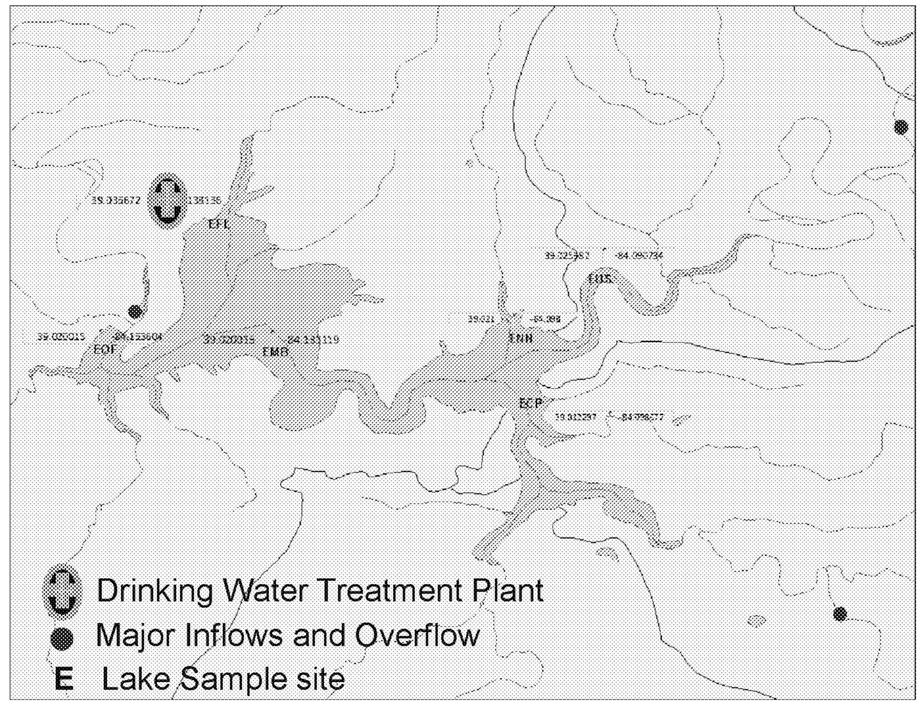
East Fork Watershed: Monitoring Program Design



Spatially and temporally dense monitoring program – headwaters to main stem



Härsha Lake sampling sites

Nutrient loading trends and relative abundance of potentially toxic cyanobacteria

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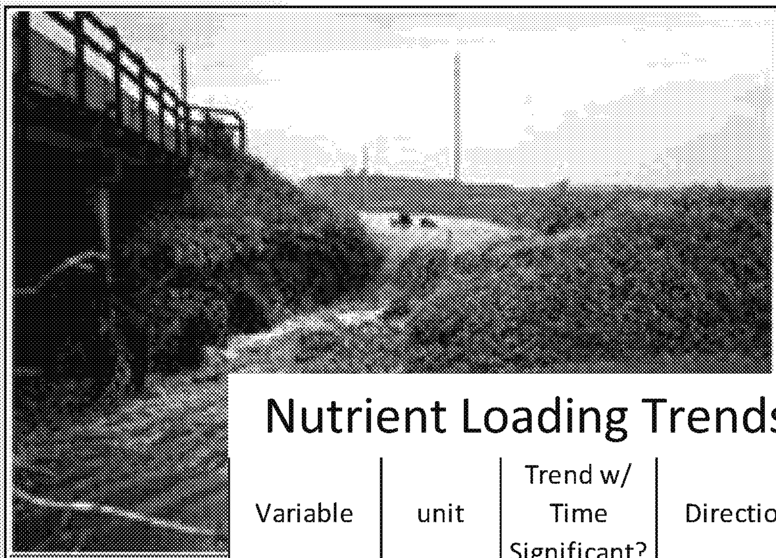
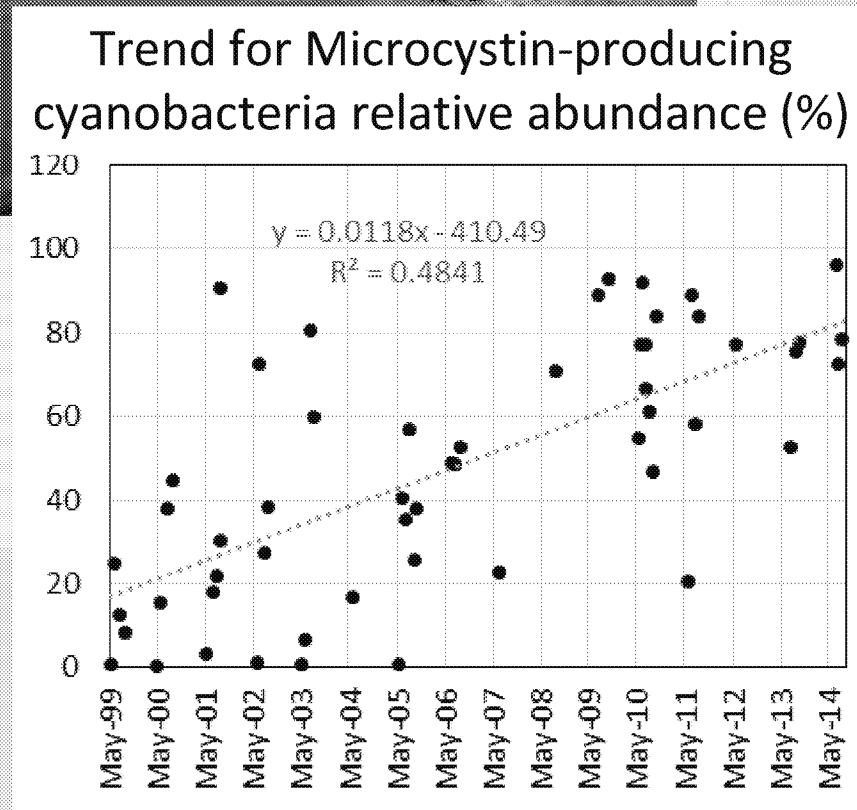


Nutrient Loading Trends

Variable	unit	Trend w/ Time Significant?	Direction
Flow	cfs	yes	Increasing
TP	µg/L	yes	Increasing
TRP	µg/L	yes	Increasing
OrgP	µg/L	yes	Increasing
TN	µg/L	yes	Decreasing
TNO23	µg/L	no	-
TNH4	µg/L	yes	Decreasing
OrgN	µg/L	yes	Decreasing
TPLoad	kg	yes	Increasing
TRPLoad	kg	yes	Increasing
OrgPLoad	kg	yes	Increasing
TNLoad	kg	yes	Increasing
TNO23Load	kg	yes	Increasing
TNH4Load	kg	no	-
OrgNLoad	kg	yes	Increasing



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One Problem – Setting Nutrient Targets

- We don't know what level of watershed nutrient load reduction is required to fix the algae problem in Harsha Lake!
  - Depends on the role of lake sediments and other internal nutrient cycling processes
  - For now adopt targets set by Ohio EPA for streams/rivers discharging to source waters and reference conditions
  - Important because participation will depend on the level of certainty that watershed nutrient reductions will fix the lake algae problem
- We need a lake model that we have high confidence in to handle this aspect. This research is in the works.

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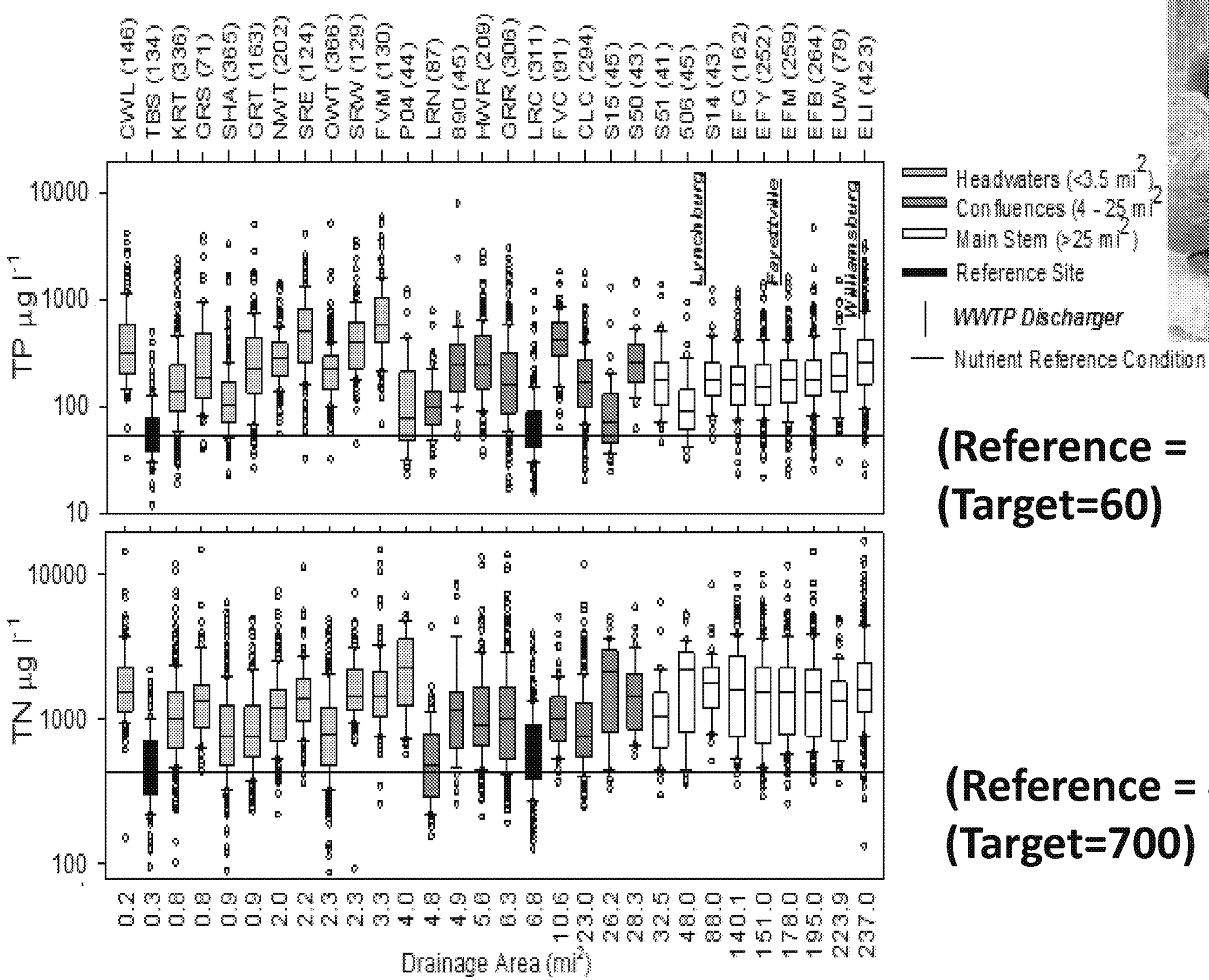
Existing Conditions and WQ Targets



(Reference = 55 ppb)
(Target=60)

(Reference = 433 ppb)
(Target=700)

Ecological Modeling for Source Water Protection

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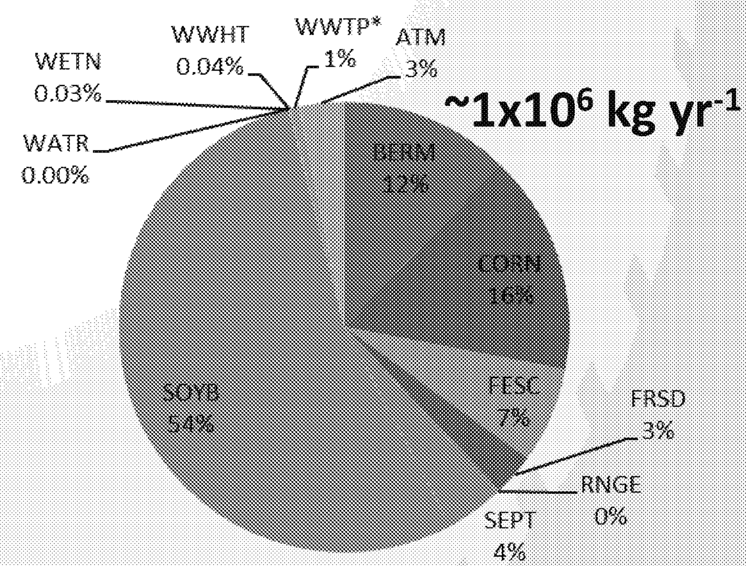
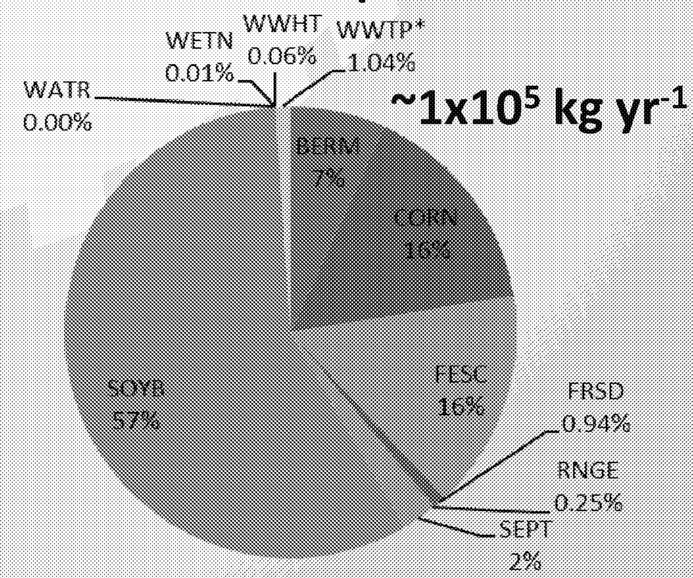
- **Soil and Water Assessment Tool (SWAT)**
  - simulates many crop types and management options. Incorporates point sources and septic systems
  - Integrates monitoring data to system scale
  - Simulates nutrient management
- **SWAT- Calibration and Uncertainty Program (CUP)** for <u>uncertainty</u> analysis
- The East Fork SWAT **model simulates lot-level nutrient loads that scale to the watershed level**
  - Validated with extensive monitoring data
  - Testing results against 'more common' parameterization of the model

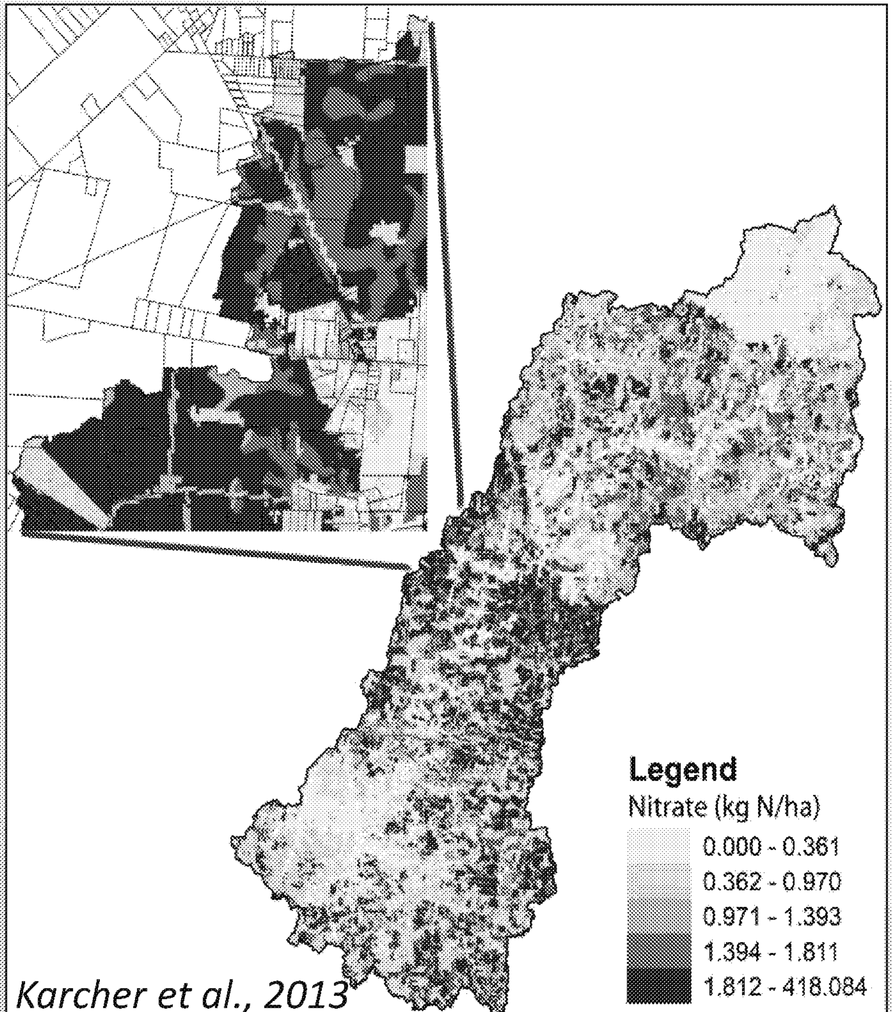
Total Nitrogen

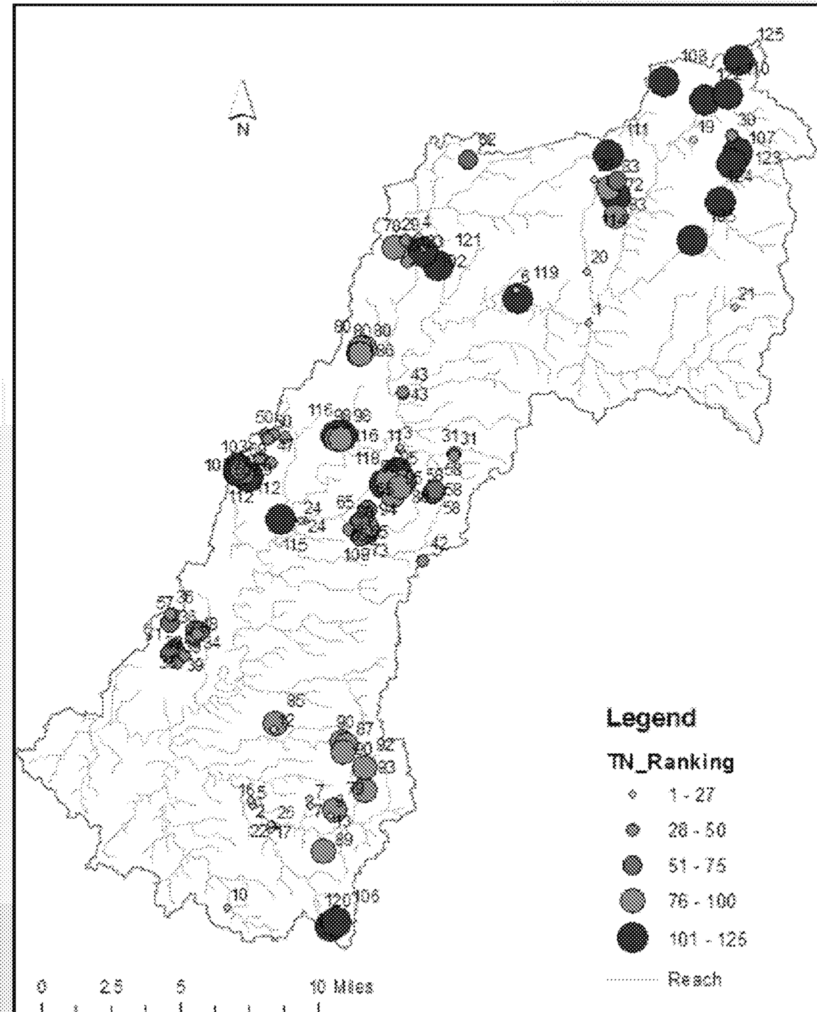


Total Phosphorus



The EFW SWAT Application



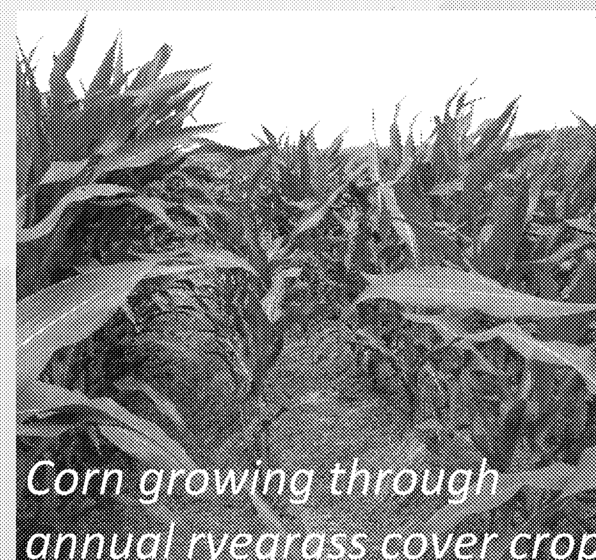


Spatial Resolution for Nitrogen loading – Lot-level loads can be elucidated

Ranked TN Loads among farmer's fields applying for agBMP funding

Fixing the Nutrient Problem

- **85K kg·yr^{-1} TP and 800K kg·yr^{-1} TN reduction needed watershed wide –**
  - from WWTP upgrades, agBMPs and septic system repairs
- **9 WWTPs in the UEFW**
  - 1768 kg TP·yr^{-1} reduction needed
  - 6433 kg TN·yr^{-1} reduction needed
- **WWTPs nutrient reduction would account for at most 2% of the nutrient reduction needed**
- **Allowing the WWTPs to purchase nutrient reduction credits** despite the low impact establishes a nutrient trading market
  - Would act to increase agBMP adoption
  - Provides a mechanism for a DWTP operation to participate in source water protection



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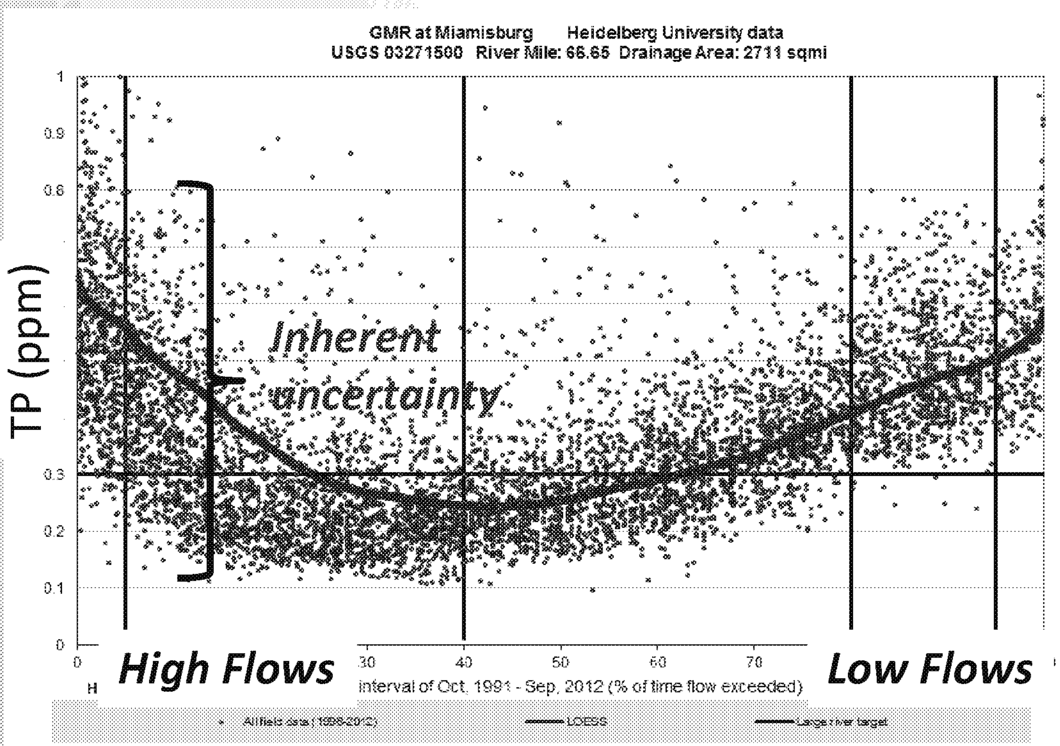
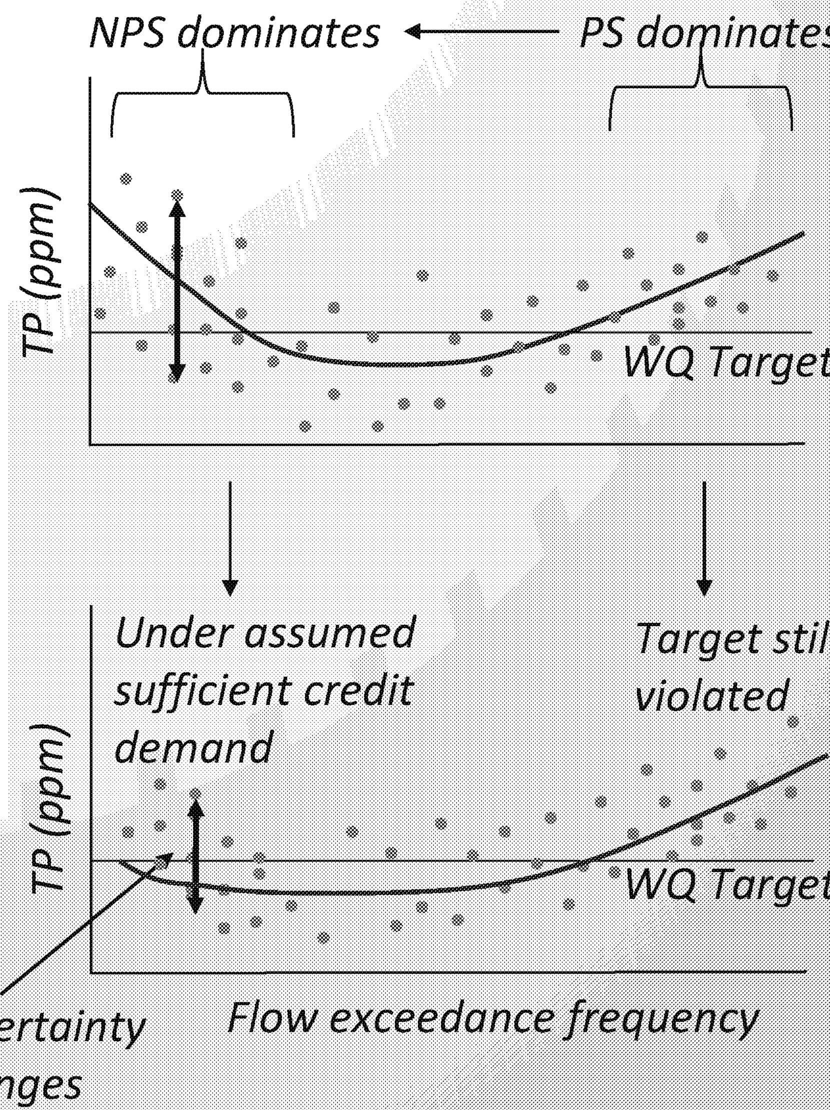
Reality Check for WQT – Meeting WQ Targets

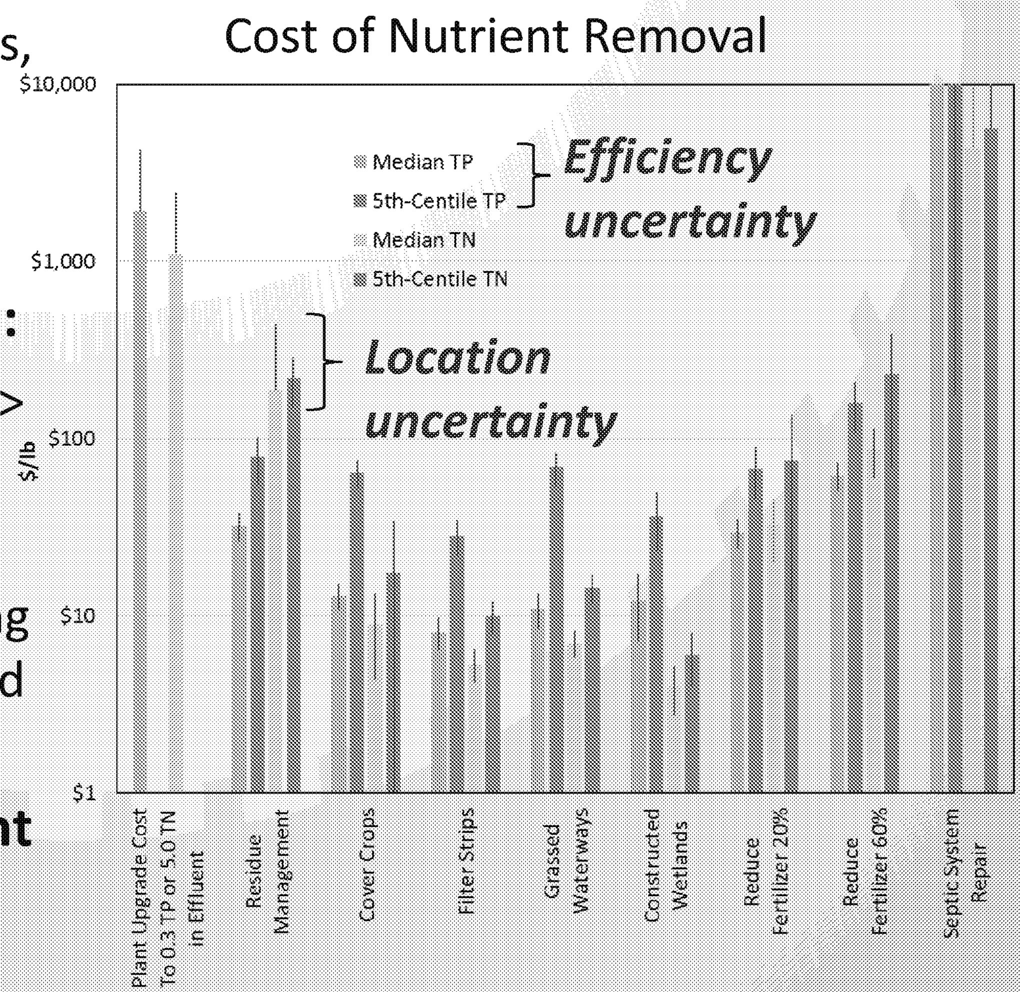


TP concentration in the Great Miami River



Plant upgrades vs. agBMP costs

- **agBMPs scenarios:**
  - Residue Management, Cover Crops, Filter Strips, Wetlands, Grassed Waterways, Septic Repair, and Reducing Fertilizer
- **In terms of $/lb nutrient removal:**
  - Septic Repair >> WWTP upgrade >> agBMPs
- **Costs among agBMP types differ**; some strategies not worth considering further (i.e., residue management and fertilizer reductions)
- **Including uncertainty in treatment efficiencies** doubles or triples the base cost estimates



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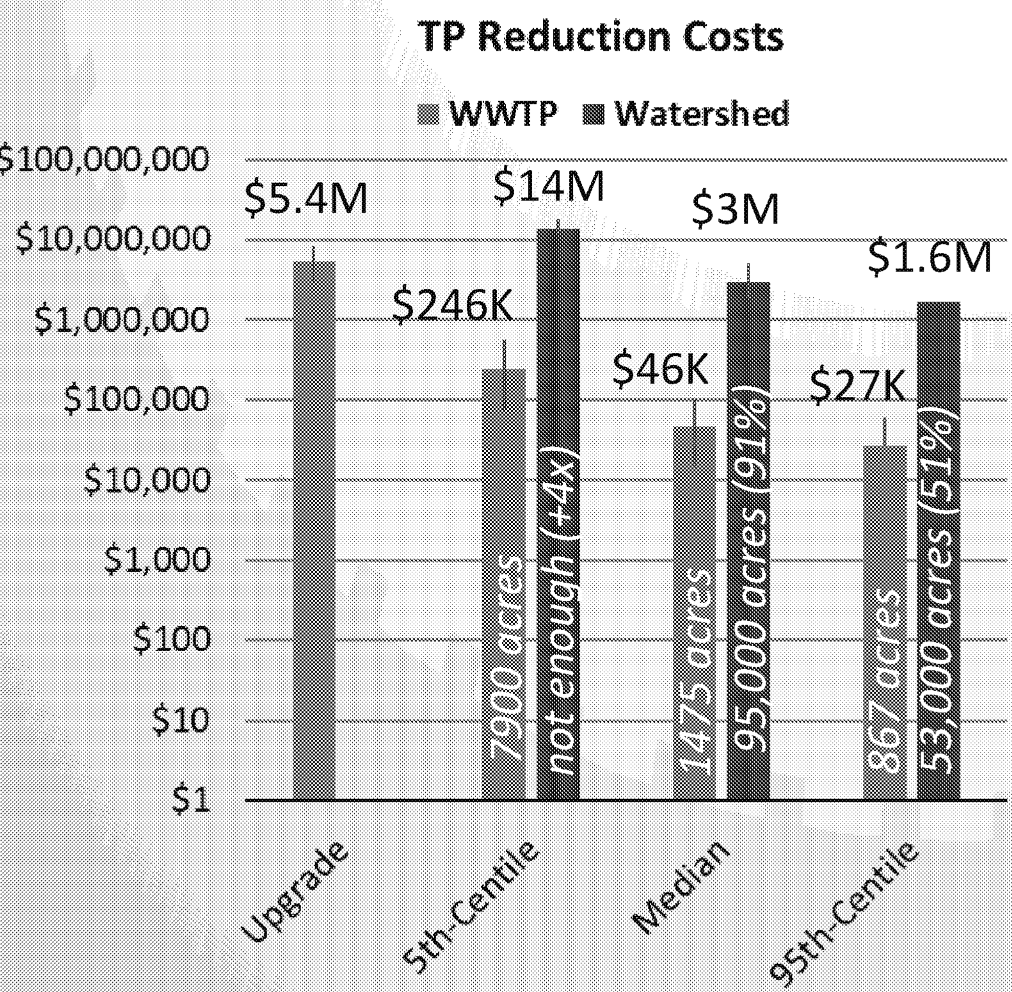
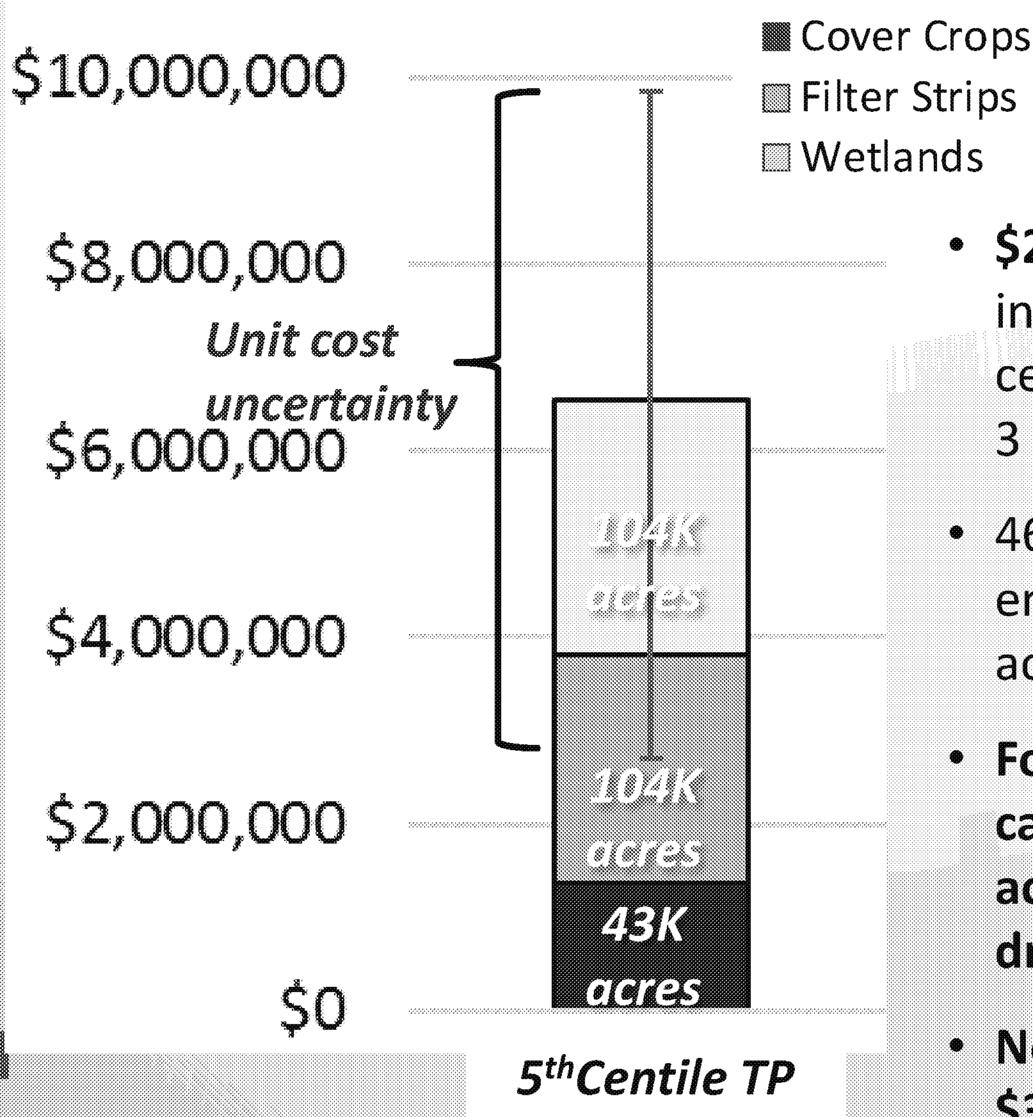
Plant Upgrades vs. Cover Crop Costs



- $5.4 million for WWTP upgrades vs. $246K for same removal (5th centile efficiency) with cover crops over 7900 acres.
- Factoring in uncertainty = a factor of 9 difference in annual cost.
- At the watershed scale: Cover crop acreage is ½ of the existing row crop acreage to not enough available:
  - The TP problem cannot be fixed with cover crops alone at the 5th centile efficiency

Watershed Nutrient Reduction Costs



- **\$2.7 – \$9.8Mil annually** to fix **TP** in the watershed at the 5th centile removal efficiency, needs 3 BMPs.
- 46% to 100% of the **TN** enrichment problem would be accounted for pending efficiency
- **For context, the DWTP spends ca. \$700K yr^{-1} for granulated activated carbon to keep drinking water safe**
- **Net revenue from row crops is \$30Mil annual**

Conclusions and Next Steps

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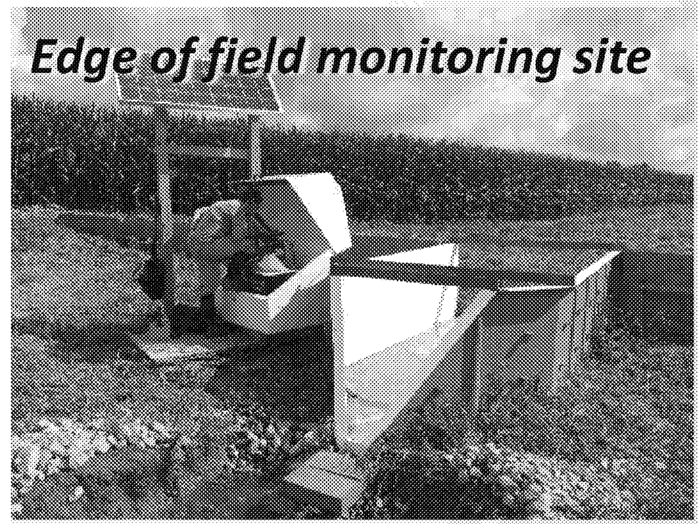
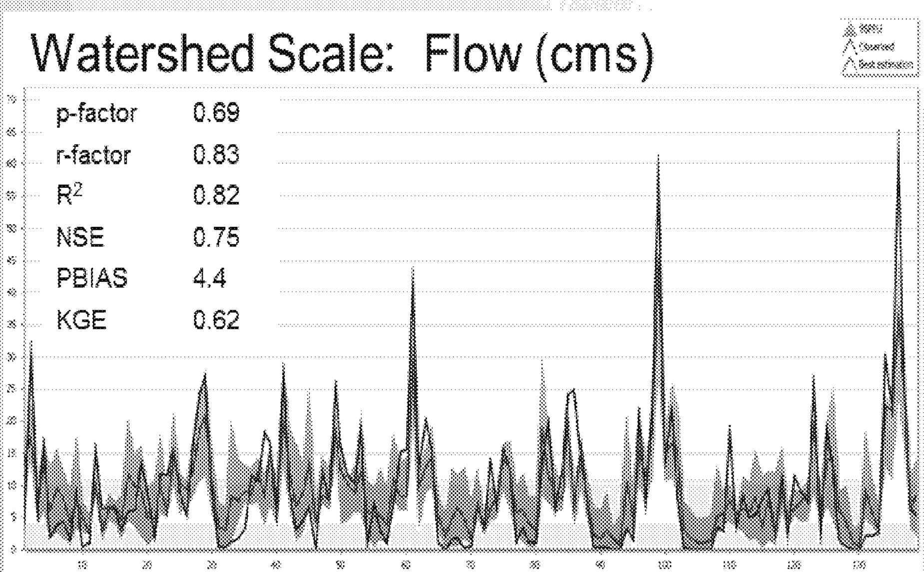
- With the low demand from WWTPs for nutrient credits relative to the watershed-wide reduction need, a trading market with only traditional participants will not meet WQ goals
- However, allowing nutrient trading would help increase the adoption rate of agBMPs, a big hurtle to overcome, and would provide a path to participation for other interested parties
- The type of full uncertainty accounting shown here should lend more confidence in cost projections and implementation plans among stakeholders
- Now the EFWCoop works to verify agBMP effectiveness and establish a lake modeling project to link algae and nutrient loads
- Remaining uncertainty: Legacy nutrients and changing physio-chemistries in the lake could pose a long term management problem

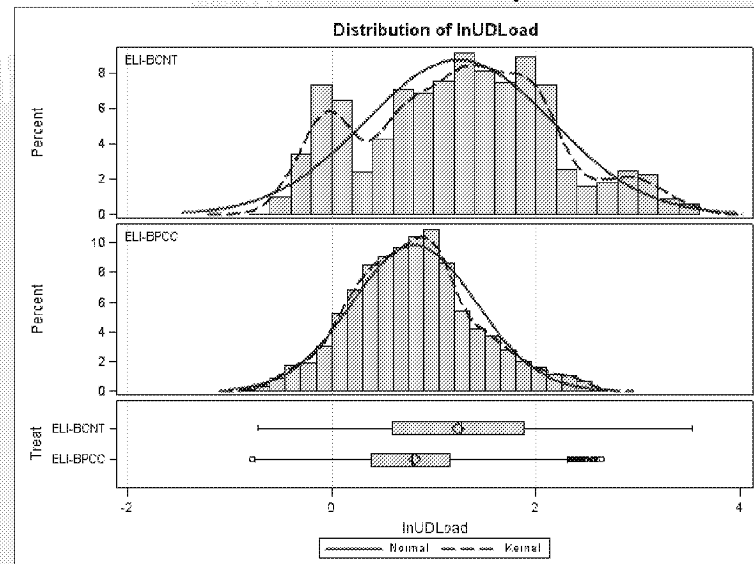


Supplementary Material: Uncertainty Analysis

This Study – Run 8 BMP scenarios 100 times each - calculate uncertainty at each point source and other points of concern

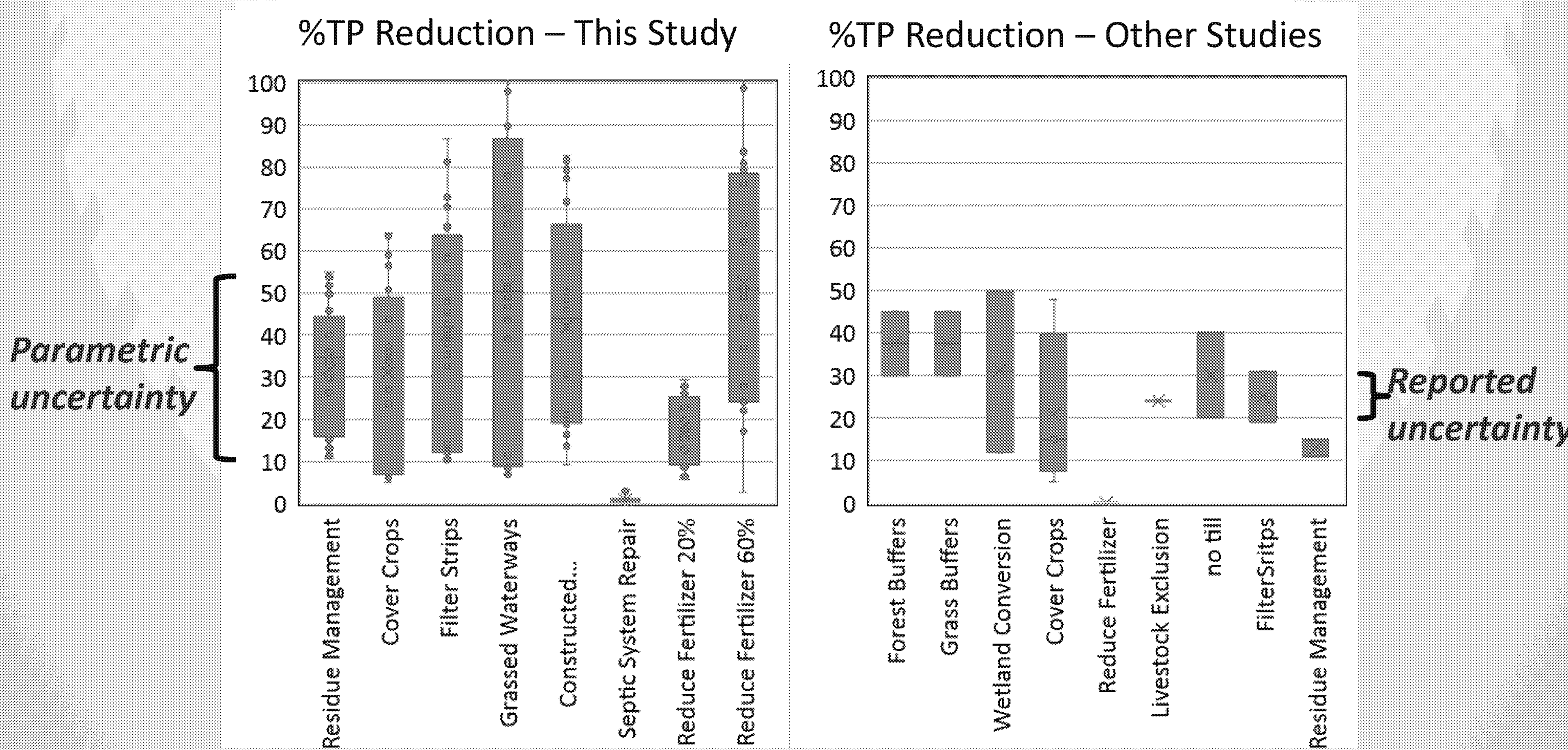
TN load distribution with and without cover crop BMP





Other Studies– Use calibrated model simulation and differences among locations to estimate an average across watershed

Supplementary Material: agBMP Removal Efficiencies



- Use the 5th-centiles of the model derived agBMP efficiency distributions
- Conservative and more systematic means of accounting for uncertainty instead of applying a trade ratio or margin of safety

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Supplementary Material: References

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